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Original Research Article

Evaluation of Seasonal Fluctuations in Metabolic and Lipid Profiles in Healthy Adults

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Abstract:

Introduction: Seasonal changes have been shown to significantly affect animal physiology and behavior. Similarly, human physiology is sensitive to environmental shifts, including seasonal changes. Research has demonstrated that conception rates, birth rates, immune responses, metabolism, and body composition exhibit seasonal patterns. This study aimed to investigate whether body fat percentage (BF%), basal metabolic rate (BMR), and serum lipid levels vary seasonally in healthy, sedentary urban adults at the end of summer and winter.

Materials and Methods: This cross-sectional study examined the seasonal variations of BF%, BMR, and serum lipids in 54 healthy, sedentary urban adults (41 males and 13 females) aged 20-60 years. Anthropometric data, including age, sex, weight, height, waist circumference, and hip circumference, were collected. Venous blood samples were taken to measure fasting serum lipid levels. BF% was determined using dual-energy X-ray absorptiometry (DEXA) scans, and BMR was calculated using the Harris–Benedict equation based on height, weight, and age.

Results: The study found significant seasonal variations in BF%, BMR, total cholesterol, triglycerides, low-density lipoprotein (LDL), and high-density lipoprotein (HDL) among all participants. Notably, significant seasonal variations in BF% and LDL were observed within the obese subgroup of participants.

Conclusion: There is a seasonal variation in BF%, BMR, and serum lipids between the end of summer and the end of winter. Additionally, a positive correlation exists between body mass index (BMI) and BF%, BMR, LDL, and HDL. Similarly, a positive correlation is observed between BF% and BMI, BMR, HDL, and LDL.

Keywords: Seasonal Variation, Basal Metabolic Rate; Body Fat Percentage; Serum Lipids.

Introduction

Animal physiology and behavior have been shown to be significantly influenced by seasonal changes. The mating behavior of seasonal breeders and the migratory patterns of birds are regulated by variations in temperature, daylight duration, and the availability of food and habitat space. Moreover, the timing of these behavioral adaptations is controlled by an internal time-keeping mechanism located in the suprachiasmatic nucleus of the hypothalamus. These behavioral changes are accompanied by functional changes. For instance, in seasonal breeders, hypothalamic sensitivity to estrogen increases during the breeding season, leading to a transition from a non-breeding to a breeding state [1-3]. Similar physiological alterations are observed in metabolic functions and their impact on body composition. Research on Chinese bulbuls (Pycnonotus sinensis) demonstrated that body mass and body fat (BF) exhibit seasonal variations, with higher values recorded in spring and winter compared to summer and autumn [4]. BF was particularly elevated in winter. Another study on European badgers (Meles meles) revealed that resting metabolic rate (RMR) peaked in summer and was lowest in winter [5].

Human physiology also responds to seasonal environmental changes, showing variations in conception rates, birth rates, immune responses, metabolism, and body composition. A study conducted in the Netherlands on adults highlighted that body mass index (BMI) and waist circumference were higher in spring and winter than in summer and autumn. This study also noted that seasonal variation was more pronounced for abdominal obesity compared to general obesity in both men and women [6-8]. Based on these findings, we proposed to investigate the seasonal variation in body fat percentage (BF%), basal metabolic rate (BMR), and serum lipid levels in healthy, sedentary urban adults during two seasons: the end of summer and the end of winter. The measurements at the end of these seasons aimed to capture the cumulative effects of each season.

Material and Methods

The study involved 54 healthy sedentary urban adults, comprising 41 males and 13 females, aged between 20 and 60 years. Individuals treated for metabolic diseases, such as diabetes mellitus, metabolic syndrome, dyslipidemia, or hormonal disorders like Cushing syndrome, as well as those on medications affecting serum lipid levels, were excluded. Pregnant women were also excluded, and female participants underwent a pregnancy test 48 hours before the study. Participants were selected using consecutive random sampling on a first-come, first-served basis, adhering to the inclusion and exclusion criteria. Written informed consent was obtained in the language best understood by each participant. The selected volunteers were assessed twice: once at the end of summer and again at the end of winter.

Participants fasted overnight for eight hours before reporting to the department, where their anthropometric data, including age, sex, weight, height, waist circumference, and hip circumference, were recorded. Body weight and height were measured without shoes and with participants wearing light clothing. Venous blood samples were collected to measure fasting glucose and lipid levels, with approximately 2 ml of blood drawn into plain vacutainers. These samples were analyzed using an automated analyzer, with quality control checks performed using internal quality control before analysis. BF% was assessed using a DEXA scan. They were instructed to lie supine on the DEXA table for a whole-body scan. BMR was calculated using the Harris–Benedict equation, based on height, weight, age, and gender.

Results

According to Table 1, anthropometric data such as weight, height, BMI, and waist-hip ratio did not exhibit significant seasonal variation. However, significant seasonal variation was observed in body fat percentage (BF%) and basal metabolic rate (BMR) among the overall population. The height for the overall participants was 156.83 ± 10.97 cm, for the lean category was 156.1 ± 11.94 cm, for the overweight category was 156.3 ± 9.56 cm, and for the obese category was 165.81 ± 10.08 cm, during both summer and winter.

Table 1: Anthropometric parameters, BF% and BMR amongst study participants

Parameters	Summer	Winter	P Value
BMI (Kg/m²)			
Overall	27.26 ± 5.97	25.62 ± 6.77	0.75
Lean	20.37 ± 0.64	20.40 ± 2.46	0.43
Overweight	28.97 ± 1.46	26.11 ± 1.62	0.75
Obese	35.41 ± 2.26	32.04 ± 2.20	0.63
Weight (Kg)			
Overall	69.22 ± 20.72	62.82 ± 22.88	0.77
Lean	48.36 ± 2.98	46.93 ± 9.31	0.41
Overweight	70.82 ± 8.55	64.03 ± 8.86	0.76
Obese	88.73 ± 15.93	97.00 ± 17.19	0.82
BF%			
Overall	31.75 ± 9.28	32.46 ± 9.87	<0.05
Lean	24.98 ± 1.95	23.47 ± 6.75	0.17
Overweight	39.84 ± 5.98	37.05 ± 5.09	0.09
Obese	38.70 ± 3.82	41.51 ± 4.01	<0.05
BMR (calories)			
Overall	1442.02 ± 277.56	1494.76 ± 269.52	<0.05
Lean	1273.04 ± 46.01	1299.16 ± 164.18	0.21
Overweight	1370.57 ± 230.76	1413.58 ± 224.1	0.19
Obese	1608.16 ± 315.8	1740.22 ± 291.69	0.23
Waist/Hip Ratio			
Overall	0.91 ± 0.06	0.90 ± 0.06	0.93
Lean	0.91 ± 0.07	0.86 ± 0.05	0.63
Overweight	0.94 ± 0.04	0.93 ± 0.02	0.34
Obese	1.05 ± 0.07	0.97 ± 0.07	0.86

In Table 2, significant variations were noted in total cholesterol, triglycerides, low-density lipoprotein (LDL), and high-density lipoprotein (HDL) among the overall participants. Specifically, significant seasonal variation in HDL was observed in the lean category, in triglycerides only in the overweight category, and in LDL only in the obese category.

Table 2: Seasonal variation in Lipid profile amongst study participants

Parameters	Summer	Winter	P Value
Triglycerides (mg/dl)			
Overall	159.41 ± 85.24	167.24 ± 85.35	0.94
Lean	140.59 ± 24.61	151.68 ± 85.24	0.67
Overweight	154.42 ± 105.71	209.69 ± 141.83	0.05
Obese	214.72 ± 49.41	177.53 ± 46.28	0.16
HDL (mg/dl)			
Overall	40.65 ± 16.52	46.48 ± 16.63	<0.05
Lean	51.39 ± 5.85	60.72 ± 20.88	<0.05
Overweight	34.01 ± 10.41	39.79 ± 7.94	0.21
Obese	37.54 ± 5.46	36.53 ± 3.55	0.23
LDL (mg/dl)			
Overall	96.99 ± 33.50	82.44 ± 25.42	<0.05
Lean	79.71 ± 9.04	75.6 ± 31.31	0.19
Overweight	108.12 ± 32.92	101.92 ± 37.14	0.09
Obese	108.03 ± 28.71	86.46 ± 13.79	<0.05
Total cholesterol (mg/dl)			
Overall	189.06 ± 36.32	191.70 ± 39.36	<0.05
Lean	164.67 ± 7.96	175.09 ± 28.68	0.55
Overweight	171.63 ± 49.88	214.0 ± 56.60	<0.05
Obese	182.05 ± 23.14	203.03 ± 23.08	0.27

Table 3 shows a significant seasonal variation in BF% and BMR between genders, both in males and females. It's noteworthy that BF% was higher in females compared to males, and in both genders, the mean BF% was higher in summer.

Table 3: Gender variation in Anthropometric parameters, BF% and BMR

Parameters	Summer	Winter	P Value
BMI (Kg/m²)			
Male	26.23 ± 6.43	26.28 ± 6.20	0.87
Female	30.60 ± 2.55	30.73 ± 2.50	0.69
Weight (kg)			
Male	68.62 ± 23.45	68.79 ± 23.04	0.81
Female	70.73 ± 7.26	71.72 ± 6.69	0.58
BMR (calories)			
Male	1516.73 ± 280.11	1528.71 ± 277.29	0.14
Female	1344.7 ± 116.38	1387.69 ± 95.35	0.08
Waist/Hip Ratio			
Male	0.92 ± 0.08	0.92 ± 0.07	0.95
Female	0.92 ± 0.03	0.92 ± 0.04	1.00
BF%			
Male	28.62 ± 8.27	27.80 ± 8.08	<0.05
Female	46.31 ± 2.07	44.68 ± 1.77	<0.05

Regarding Table 4, both genders exhibited higher cholesterol levels in winter than in summer, although these levels remained within the normal range. Triglyceride levels were higher in winter for males and higher in summer for females, with males showing levels above the normal range. LDL levels were higher in summer for both genders, while HDL levels were higher in winter for both males and females.

Table 4: Gender variation in Lipid profile amongst study participants

Parameters	Summer	Winter	P Value
TG (mg/dl)			
Male	162.46 ± 89.56	189.5 ± 94.52	0.63
Female	143.69 ± 72.94	123.91 ± 32.21	0.43
HDL (mg/dl)			
Male	47.84 ± 17.78	50.72 ± 17.8	<0.05
Female	34.05 ± 8.58	36.28 ± 6.13	0.13
LDL (mg/dl)			
Male	95.24 ± 35.08	80.75 ± 28.63	<0.05
Female	105.76 ± 30.6	80.48 ± 15.92	0.07
Total cholesterol (mg/dl)			
Male	190.14 ± 39.01	194.52 ± 41.85	<0.05
Female	183.78 ± 27.91	191.21 ± 35.54	0.38

Table 5 indicates a strong correlation between BF% and BMI, BMR, and HDL in both seasons, and with LDL only in summer. Similarly, Table 6 demonstrates a strong correlation between BMI and BMR, BF%, HDL, and LDL

Table 5: Correlation coefficients of BF% versus various parameters

Parameters	Summer	Winter	Significance
BMI	0.746	0.832	99% significant
BMR	0.348	0.427	95% significant
Cholesterol	0.2	0.288	Not significant
HDL	-0.505	-0.49	99% significant
LDL	0.41	0.265	Summer is 95%, winter is not
TG	0.343	0.174	Not significant

Table 6: Correlation coefficients of BMI versus various parameters

Parameters	Winter	Summer	Significance
BF%	0.841	0.746	99% significant
BMR	0.719	0.661	99% significant
Cholesterol	0.335	0.271	Not significant
HDL	-0.514	-0.514	99% significant
LDL	0.357	0.389	95% significant
TG	0.213	0.319	Not significant

Discussion

The findings of our study indicate significant seasonal variations in body fat percentage (BF%), basal metabolic rate (BMR), and serum lipids among the study population. BF% is notably higher in summer compared to winter across the general population and within the obese BMI category. This contrasts with some studies that reported no seasonal variation in BF% and BMI, likely due to behavioral adaptations and technological advancements mitigating temperature changes [9,10].

In our study, the observed reduction in BF% during winter suggests fat loss, as winter measurements were taken after summer. This trend could be attributed to the mild winters, which do not induce a state of rest similar to hibernation in animals. Consequently, physical activity levels remain consistent between seasons, and the increase in BMR observed in winter supports the reduction in BF%. While there is no consensus on seasonal BMR variation, some studies report higher BMR in winter [9,11,12], while others do not [10].

When participants were categorized by BMI into lean, overweight, and obese groups, the seasonal pattern remained consistent with the overall population. Gender-wise analysis showed that BF% was higher in summer for males and higher in winter for females. Notably, our study's participants had a higher mean BMI in summer, potentially due to high-fat non-vegetarian diets typical of the community. Ethnic factors, such as the naturally stocky body type of these individuals, may also contribute [13,14]. Similar trends are observed in other communities, such as Chinese and Malays, who exhibit lower BF% at comparable BMIs [15]. The higher BF% at lower BMI aligns with observations in Asian Indians [16-18]. Further investigation is needed to understand the health implications of these findings.

Regarding serum lipids, total cholesterol, triglycerides, and HDL levels were significantly higher in winter, except for LDL, which was higher in summer. Gender-specific analysis showed that total cholesterol, triglycerides, and HDL were higher in winter for males, while only total cholesterol and HDL were higher for females. These findings are consistent with studies from the University of Colorado Health Sciences Center and Mayo Clinic, which reported higher lipid levels in winter [19-21]. Seasonal variations in serum lipids are often attributed to hemoconcentration due to plasma volume contraction in response to cold and possible dehydration during winter [20]. Dietary factors, such as increased fat and saturated fat intake in winter, may also play a role [21].

Our study also found positive correlations between BMI and BF%, LDL, and HDL, and between BF% and total cholesterol, LDL, HDL, and triglycerides, consistent with global studies [22-25]. However, our study's limitations include the indirect estimation of BMR using the Harris–Benedict equation and the timing of data collection at the end of summer and winter, rather than peak seasons. Including data from spring and autumn could provide a more comprehensive understanding of seasonal variations. Despite these limitations, our findings on seasonal variations in BF%, serum lipids, and BMR could influence clinical assessments of dyslipidemia and obesity.

Conclusion

Our study demonstrates a seasonal variation in body fat percentage (BF%), basal metabolic rate (BMR), and serum lipid levels between the end of summer and the end of winter. We observed positive correlations between body mass index (BMI) and BF%, BMR, LDL, and HDL. Additionally, a positive correlation exists between BF% and BMI, BMR, HDL, and LDL. These findings could serve as a valuable reference for clinicians when interpreting serum lipid levels, taking into account the potential seasonal effects that may cause an increase in serum lipids at the end of winter or a decrease at the end of summer.

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